Analysis of DPOAE fine structure of 12 symphony orchestra musicians

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Analysis of DPOAE fine structure of 12 symphony orchestra musicians

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1. Objectives

In this study distortion product otoacoustic emission (DPOAE) are measured with high frequency resolution for a group of musicians before and after rehearsal. The DPOAE fine structures are analyzed and described by three parameters (ripple width, ripple height, number of ripples). Hearing thresholds are also measured before and after rehearsal. It is analyzed, whether the exposure during rehearsal causes temporary changes in the auditory system, e.g. a temporary threshold shift (TTS) or changes in the DPOAE.

2. Background

When DPOAEs are measured with sufficient high frequency resolution, DPOAE fine structures are revealed with almost equidistant minima and maxima. It has recently been suggested [1] that it is the prevalence and character of the fine structure that best correlate with the state of the hearing.

3. Methods

DPOAE measurement

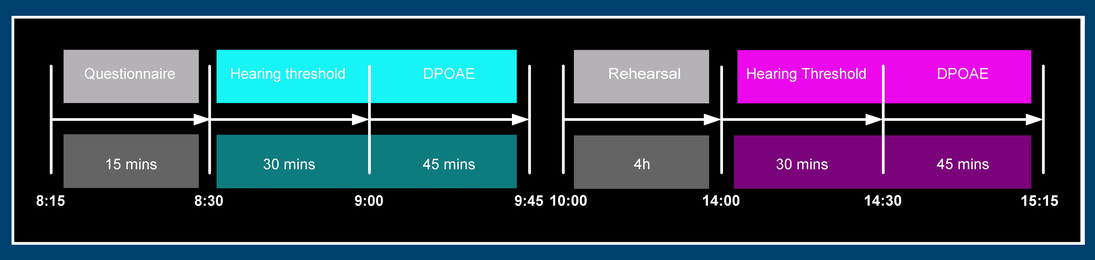
- IL096 system, Otodynamics
- 2f1-f2 DPOAE
- L1/L2=65/45 dB
- f2/f1=1.22
- 903 Hz >f2 > 6201 Hz
- Δf = 12 Hz for f2 < 3 kHz
- Δf = 24 Hz for f2 > 3 kHz

Subjects

- 12 musicians, aged 31-55 (Mean 39)
- 9 female, 3 male
  - 4 violins
  - 3 violas
  - 2 celli
  - 2 clarinets
  - 1 trombone

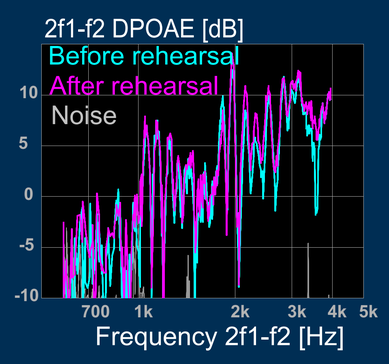
DPOAE fine structure analysis (preliminarily reported in [3])

- Determination of maxima and minima of DPOAE fine structure ripples
- Ripple width: Frequency difference between two minima
- Ripple height: Level difference between a maximum and the mean of the minima
- Number of ripples: Number of ripples >3 dB in height per 1/3 octave

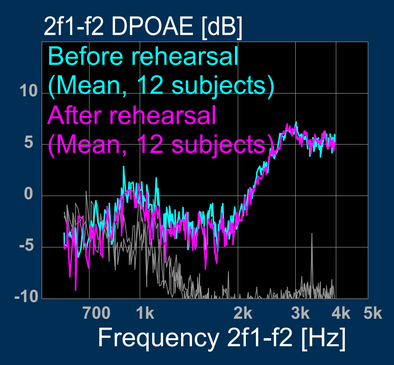


Time schedule of experiment. One subject participated per rehearsal day. Each session lasted 90 minutes, 30 minutes for the pure-tone audiometry and 60 minutes for the measurement of DPOAE fine structure. The order of testing either hearing threshold or DPOAE first was balanced.

4. Results

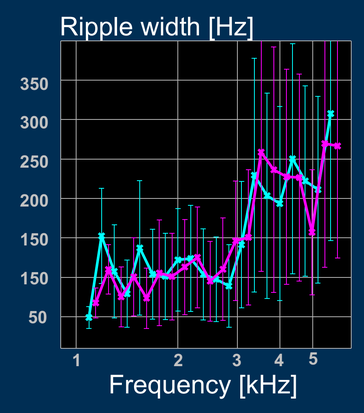


DPOAE fine structure measurement for one subject. The example features fine structure characteristics with deep notches and high peaks.

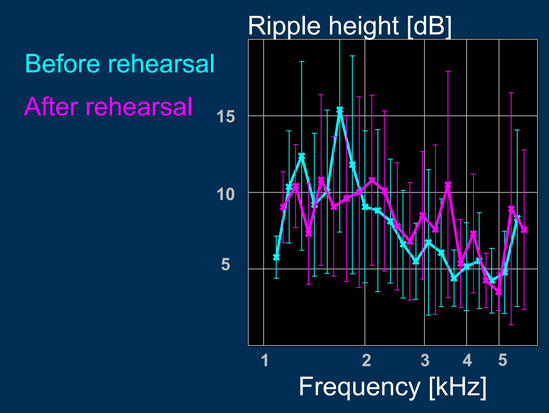


DPOAE mean of 12 subjects before and after rehearsal. The fine structure is smoothed out when the data are averaged. No significant DPOAE level shift after the rehearsal is visible.

The following figures show the fine structure parameters ripple width and ripple height averaged over 12 subjects in 1/8 octave bands. The errorbars are the standard deviations (STD) between subjects.

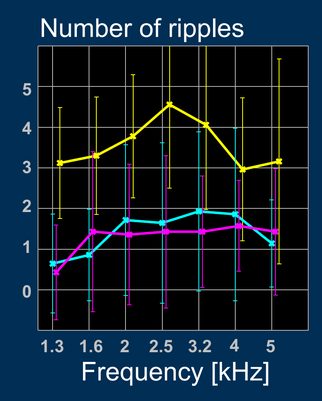


The ripple width increases with increasing frequency from 100 Hz to 250 Hz.



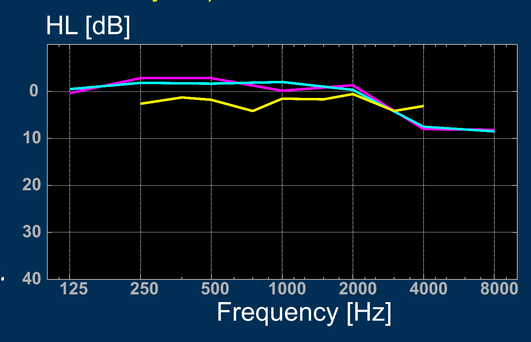
There are large STDs for the ripple height between subjects. Ripple heights vary between 3 dB and up to 32 dB.

In a previous study (reported in [3]) the DPOAE fine structure of 50 young, normal hearing students was measured. The following figures show a comparison of the fine structure characteristic "number of ripples" and the hearing thresholds of musicians and students.



Fine structure characteristic "number of ripples" for musicians and a group of younger, normal-hearing students.

Musicians, before rehearsal (Mean, 12 subjects)
Musicians, after rehearsal (Mean, 12 subjects)
Students (Mean, 50 subjects)



Hearing thresholds for musicians and students.

5. Conclusions

From the preliminary results of the data, neither the hearing threshold nor the DPOAE reflect a change in the state of the hearing of the musicians by the end of a typical day of rehearsal. When comparing the fine structure characteristics of the group of musicians to a younger group of students, the students have a higher prevalence of DPOAE fine structure ripples than the musicians.

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References

[1] Mauermann, M., Uppenkamp, S., Hengel, P. and Kollmeier, B. J. Acoust. Soc. Am., 106(6): 3484-3491, 1999.
[2] Reuter, K. and Hammershøi, D. Proceedings of Inter-Noise 2005, Rio de Janeiro, paper 1962.
[3] Reuter, K. and Hammershøi, D. Proceedings of Forum Acusticum 2005, pp. 233-236, paper 630.